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UI design development for informative mobile game about light pollution

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Abstract: Light pollution has been an environmental concern in Jakarta and surrounding cities. Despite the negative consequences, Jakarta residents have low to non-existent awareness about light pollution. To raise awareness, the development of informative mobile game with the title MA'LAM is proposed. As one means to develop an ideal gaming experience, User Interface (UI) needs to be developed with usability and aesthetic approach. To implement UI design successfully, a suitable user-centric design method is required. Therefore, Design Thinking was used to develop MA'LAM's UI design as part of User Experience (UX) development process. With a usable and aesthetically pleasing UI, message and information about light pollution could be conveyed through a positive gameplay interaction.

Keywords: UI design, informative mobile game, usability, aesthetic form, light pollution

1. Introduction

International Dark-Sky Association (IDA) defines light pollution as inappropriate/excessive artificial light use with negative environmental impact for humans, wildlife, and earth's climate. Light pollution, voiced as international concern, instigates multiple acts to combat the issue such as Globe at Night Campaign, address on UN's CMS COP13 and 2015's International Year of Light, and the pass of legislative light pollution law in countries like France, Slovenia, and South Korea (Lyytimäki, 2015).

Indonesian state-owned organizations like Jakarta Planetarium and LAPAN/PUSAINSA have voiced concern about light pollution in Jakarta. Despite being the most light-polluted city in Indonesia, most citizens from Jakarta and afflicted satellite cities have low to no awareness about light pollution. The fact is confirmed through personal interview with Widya Sawitar - Jakarta Planetarium Astronomer and light pollution awareness activist – as well as a design problem research conducted by the authors.

It is hypothesized that low awareness is caused by lack of engagement from available public information about light pollution. Creating an informative mobile game titled MA'LAM is proposed as alternative solution to raise awareness about light pollution in Jakarta. MA'LAM is targeted for users aged 16-21, live in Jakarta/surrounding cities, never heard/have misconceptions about light pollution, have access to a smartphone device, and possess interest to play mobile games. Mobile game is chosen due to audio-visual and tactile engagement qualities. UI design is implemented as an alternative to convey intended messages and information within MA'LAM through a positive gaming experience. This paper aims to propose and showcase a practice of improving mobile gaming experience through developing UI by Design Thinking Methodology.

2. Literature Reviews

2.1 Interactive Design

Norman (2013) discusses important interactive design aspects; discoverability and usability/understanding. Discoverability is users' ability to find a design's different features, and ability to access such features with ease. Usability entails understanding functions of a product's main feature, and how to utilize the designed product. User experience, aesthetic form, and quality of interaction need to be considered for any interactive design (p.4-8).

2.2 Usability Factors in Mobile Games

Hussain, Abbas, Abdulwaheed, Mohammed, & Abdulhussein (2015) define usability as interactive design's ability to be understood, learned, operated, and to attract user's attention for completing a certain goal. Usability factors are observable in mobile games' UI and can be categorized as the following:

1. **Learnability:** Degrees of ease users can complete a certain task for the first time / how quick users may improve in completing tasks.
2. **Efficiency:** The time needed to complete a certain task. To measure efficiency, users should already master tasks at hand.
3. **Memorability:** Ease of recalling game rules and mechanism after a time-break or how users may re-establish gaming skills.
4. **Errors:** Quality and quantity of mistakes made while playing a mobile game and how to overcome them.
5. **User Satisfaction:** The measure of users' satisfaction and attitude while playing a mobile game.
6. **Simplicity:** Degree of ease/comfort users experience for a certain task. This factor is also used to assess menu structures and navigation design quality.
7. **Comprehensibility:** Ease of understanding contents within a mobile game that is related to textual information and presentation.

2.3 User Interface Design

Tidwell (2011, p.1) explains User interface (UI) as an interactive medium between human and digital products. UI is not constrained to visual aspects and requires an understanding of user needs, wants, and objectives. Cooper, Reimann, Cronin, & Noessel (2014) states that users perceive attractive interfaces as more usable. It is reasoned that users put more effort into learning what they perceive as desirable interface. The claim parallels Lidwell, Holden, & Butler (2003, p.19), who claims that aesthetic design is considered more usable by users compared to a design without aesthetic value. Furthermore, a design's beauty is measurable through form-follows-function principle, described as a design's beauty which is formed by its functions (p.91). Functions are deemed more objective compared to form, hence they are considered more reliable for measuring a design's quality. Nevertheless, designers must not sacrifice a design's aesthetic aspect to optimize function and vice-versa.

2.4 User Interface Features in Mobile Game

According to Hight & Novak (2007, User Interface in mobile games includes on-screen, peripheral buttons, and device control. Due to varieties of mobile games, UI is adjustable to suit different gaming necessities (p.98). There are some distinct features found in mobile games to complete different tasks described in Table 1.

Table 1 Mobile Game's Basic UI Features

No.	Feature	Function Example
1	Navigation	controlling character's walking, jumping, flying
2	Controlling playable characters	skill activation, accessing inventory
3	Virtual world orientation	accessing map, zoom in / zoom out
4	Inventory management	equip weapons, wear armor, use item
5	Interacting with NPC	engaging in combat, start conversation
6	status monitoring	Health Points, money, experience points
7	Using special items	using keys, opening doors, opening chests
8	Accessing setting option	adjusting visual, language, buttons
9	Saving / loading game data	-
10	Joining / starting multi-player sessions	-
11	Communicating with device	-
12	Finding help / information	-
13	Stopping / quitting from game	-

3. Design Method

Soegaard (2018) suggests that UI development method should be user-centric, as it is supposed to be used by users (p. 7). For developing MA'LAM, Design Thinking was implemented due to its user-centric quality. It consists of 5 different phases which may be repeated non-linearly for iteration purposes as shown in Figure 1.

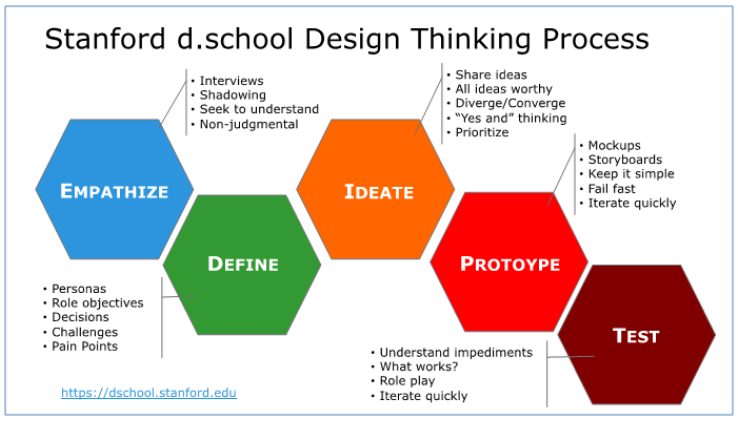

Figure 1 Design Thinking Diagram (https://tinyurl.com/y5otcdvu)

1. **Empathize:** Understanding users' point-of-view and user-centered-problems by observing users' behaviour, direct-interaction engagement, and Immersing in Users' Experience. On this project, targeted users' understanding of light pollution and media preference was gauged through series of digital surveys, interview, and field-observation.
2. **Define:** Converting findings from Empathy Phase into designer's insights and generating problem statements to be used as design solution references. For this phase, data from Empathize phase and literature study findings were combined to pinpoint problems which are addressed throughout the project. To help defining problems, mind mapping process, card-sorting, and user-personas development were utilized during the define phase.
3. **Ideate:** The phase for generating design solution alternatives in which problem-solving are approach with diverse ideas. For generating ideas of gameplay, Hight & Novak's UI features were referenced as game mechanism development. Ideas were also generated in reference to Usability Factors by Hussain, Abbas, Abdulwaheed, Mohammed, & Abdulhussein (2015) as parameters. To organize ideas, card sorting, brain-storming session, and UX diagram development were utilized. Reference Boards were also assembled generate ideas for design's art direction.
4. **Prototype:** Aside from testing functionality, prototyping phase gives a chance to gain empathy, insights, and inspiration. A wide variety/degree of outputs are possible, including sketches and digital mock-ups. For MA'LAM's design project,

the prototyping phase aims to create aesthetic visuals for boosting desirability and usability.

5. **Test:** The purpose is to gather feedback, refine solutions, and learn about users. Test Phase is conducted by creating authentic experiences for users to interact with prototypes. Methods used to gather necessary data were throygh Alpha and Beta tests, followed with distribution of digital survey for each session.

4. Design Process

The design process follows the steps of Design Thinking framework previously described in Part 3 with design deliberations derived from Part 2 of this paper. To summarize, the design process is expressed through the following figure. Furthermore, the process is to be elaborated based on major milestones during the project's design development.

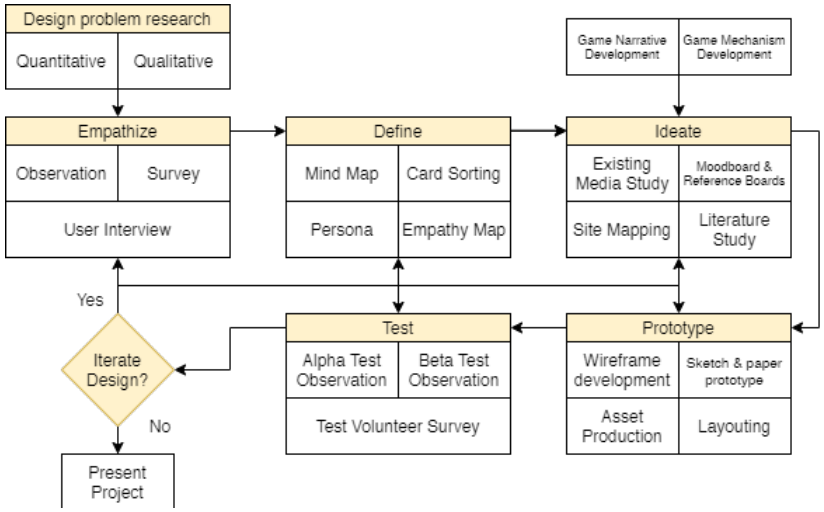

Figure 2 MA'LAM UI Design Process Diagram with Design Thinking Framework

Before starting design process, design problem research was conducted by collecting data about light pollution via Interviews, digital survey, and literature study. After research, Empathize Phase begins with on-site observation in Jakarta, conducting user interview towards targeted design users, and distributing digital survey to validate existing data. The accumulated data was then organized and redefined through generating User Personas and Empathy Map, assisted with brainstorming session via Card Sorting, and creating a mind map about design problems and media alternatives. On Define Phase, three keywords Urban, Vibrant, Sci-Fi were generated.

4.1 Gameplay Mechanism Mapping

Gameplay mechanism is planned before game aesthetics to implement form-follows-function principle. The gameplay mechanism was influenced by MA'LAM's genre (2D platformer, adventure, stealth, puzzle) and game concept (collectible objects and characters, NPC dialogues, and game storytelling to convey information about light pollution). The purpose of mapping is to create a reference for game UI development.

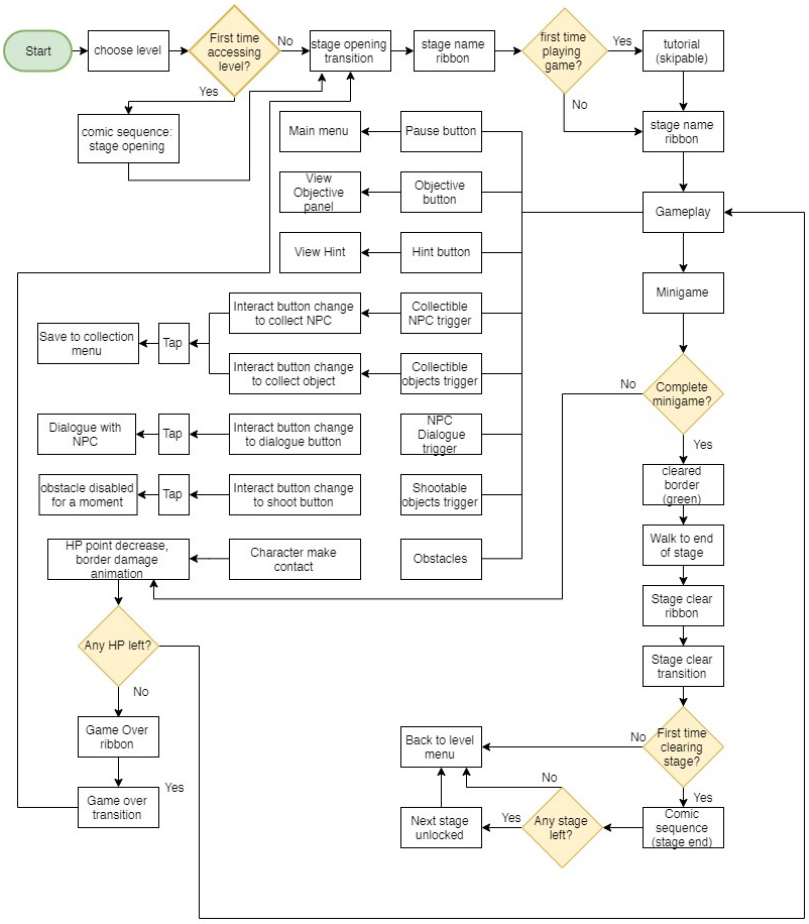

Figure 3 MA'LAM Gameplay Mechanism Flowchart

To summarize, MA'LAM is mapped into gameplay interface and menu interface. Effort for inducing engagement were focused on gameplay interface, while menu interface such as level, collection, and setting menu acts as support to induce gameplay engagement. Gameplay interface were made consistent with adjustment such as stage hint and mini-game layout being made to accommodate MA'LAM's 6 designed levels. Mini-games in the form of puzzle and quiz were designed to add gameplay engagement. In accordance to the game's sci-fi theme, both gameplay and menu interface was mapped to resemble holographic screen that interconnects through layers.

4.2 Art Direction

MA'LAM's mood board content is derived from three keywords generated from Define Phase. Images within the mood boards were also derived from artworks which ambience and style the project designers agreed upon. This implies that the mood board also affect MA'LAM's game character and environment development. For UI development, the mood board was then derived into colour board, typeface reference board, and Interface reference board. Figure 4 shows MA'LAM's designated mood board.

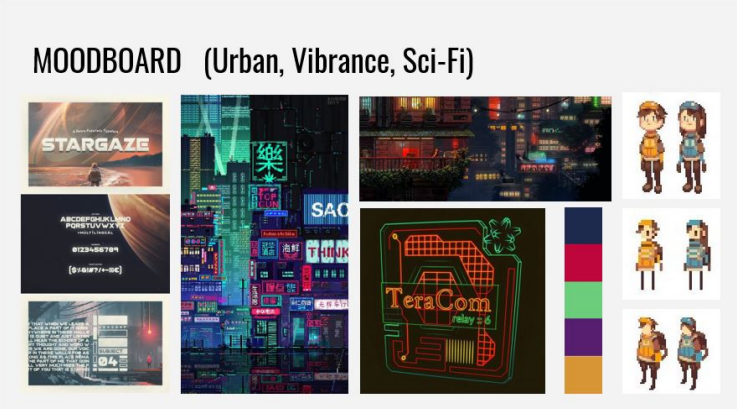

Figure 4 MA'LAM Mood Board

Figure 5 MA'LAM UI Color Palette

In addition, Pixel Art was chosen as art style due to advantages cited by Silber (2015), in particular cutting long-winded development process (by texturing, mapping, or rigging), minimize development errors due to limited human and time resource, and avoiding Uncanny Valley effect on the final artworks. As for the chosen UI color palette, Coleran on Shedroff & Noessel (2012) states Sci-Fi is associated with the color blue. A particular blue shade (#182a4d) is used as MA'LAM's primary UI color. Another colors present are red (#c21f40) to signify danger/error/failure, green (#71c379) to signify safety and success, and yellow (#d99633) to create highlight/grab attention.

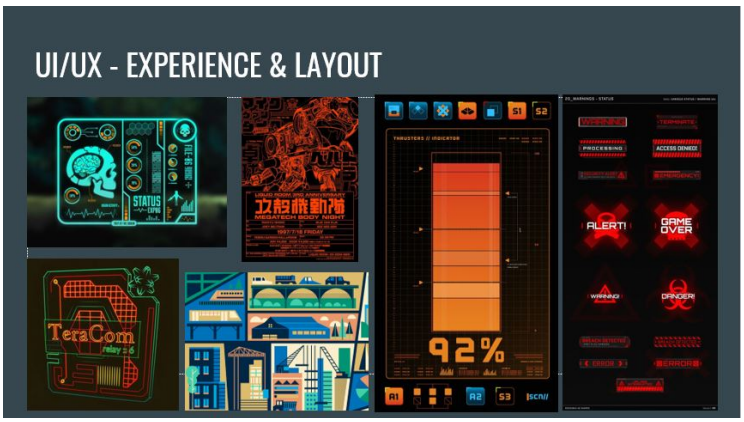

Figure 6 MA'LAM UI Reference Board

MA'LAM's UI reference board influences asset aesthetics on later prototyping phase. Shedroff & Noessel (2012) mentioned *Sci-Fi glow* as a distinct characteristic within the Scifi theme that MA'LAM aims to emulate. Holographic visuals were incorporated to induce the Sci-Fi glow effect on MA'LAM's UI design as shown in Figure 6. Other visual characteristic includes using polygonal shapes (non-rectangular) to induce advanced/sophisticated technology vibe, and manipulating transparency on visual assets to direct users' focus, induce contrast with background image & communicate relationships between layers.

4.3 User Interface Prototyping

Sketches plays an important role within the prototyping phase for integrating form and function within design assets/layouts. For example, UI Icons sketches were produced on Prototype Phase. Icons were made angular with minimum curved lines to accommodate the Pixel-Art style, sketched on a 5 x 5 cm grid paper before digitalization on 128 x 128px *canvas*. Icons were placed on buttons, panels, and interface features, so they were coloured white to induce contrast with the darker background color. Due to chosen pixel art visual style, icons were made with bold geometric lines that put emphasis on shape clarity despite its pixelated form. The Icon design development was documented on Figure 7 and 8.

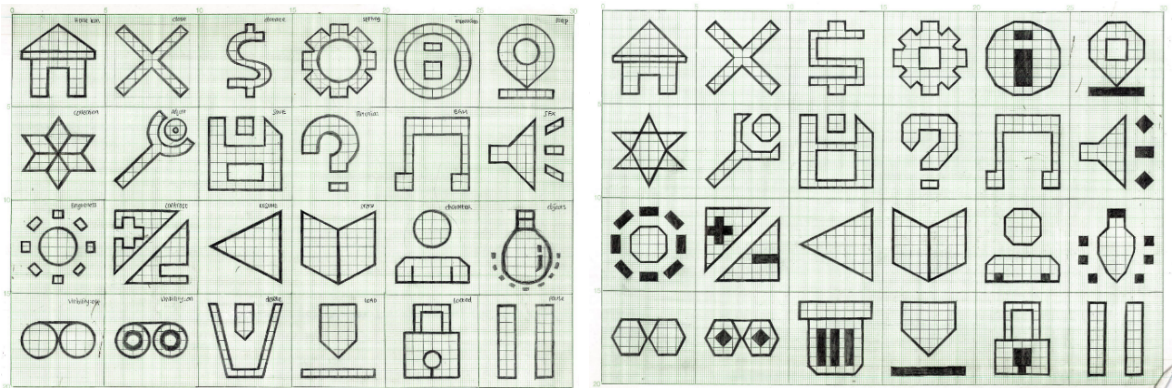

Figure 7 MA'LAM Original (left) and Iterated (right) Icon Sketches

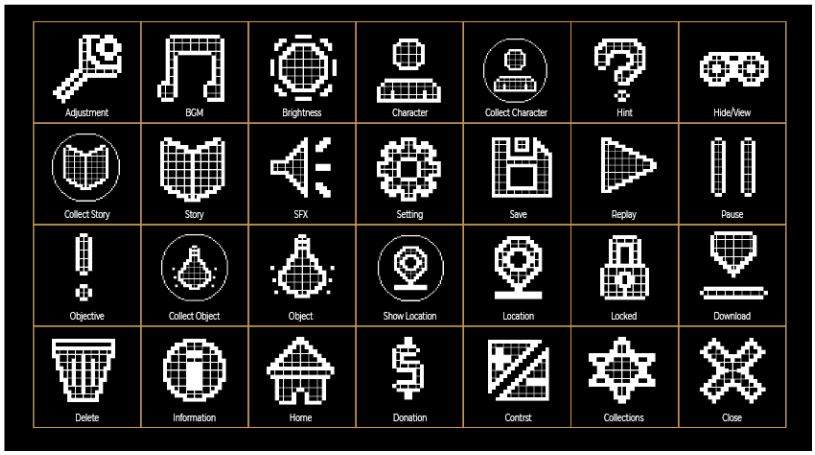

Figure 8 MA'LAM Digitalized UI Icon Set

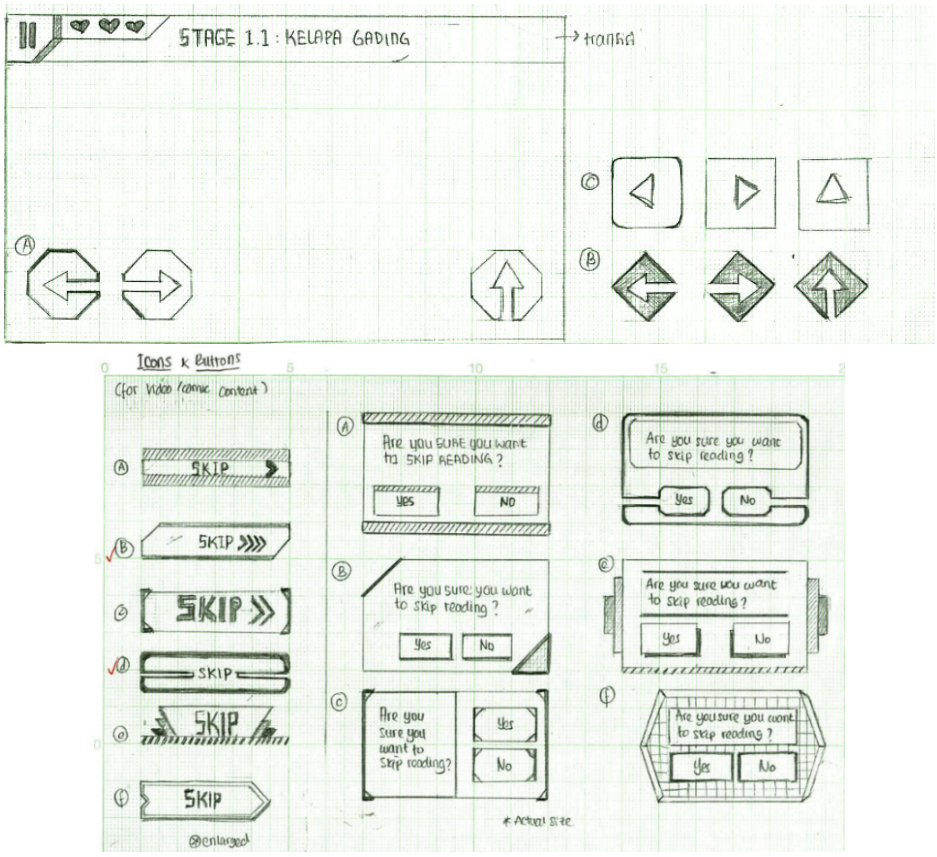

Figure 9 MA'LAM UI Asset Sketches

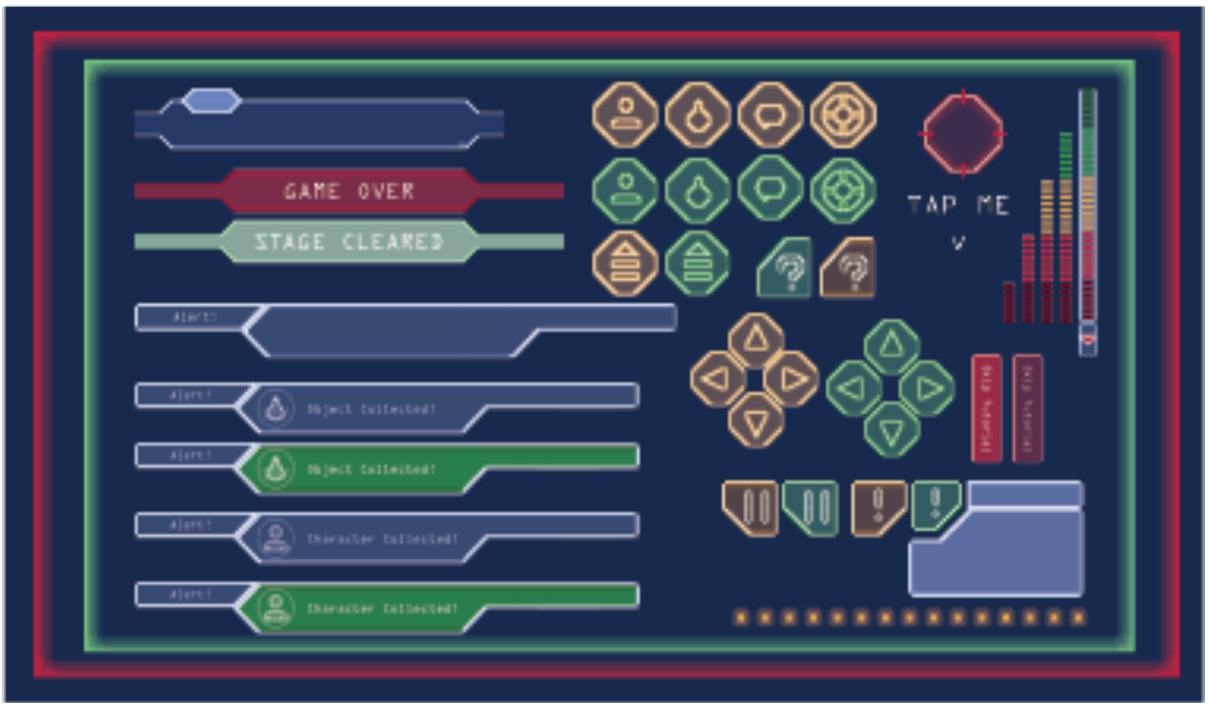

Figure 10 MA'LAM UI Asset Sketches

Similarly, UI layouts and assets were explored through sketches before digitalization. After UI layouts are finalized with wire-framing and paper prototyping, UI assets were designed on 480 x 270px canvas. The digitalized assets and asset sequences were then exported in PNG format and assembled into finalized layouts. Icons and texts were added after layouting, then complete layouts were exported along with animated UI interface reference. UI assets and layouts were received by contracted programmers for game engine assembly.

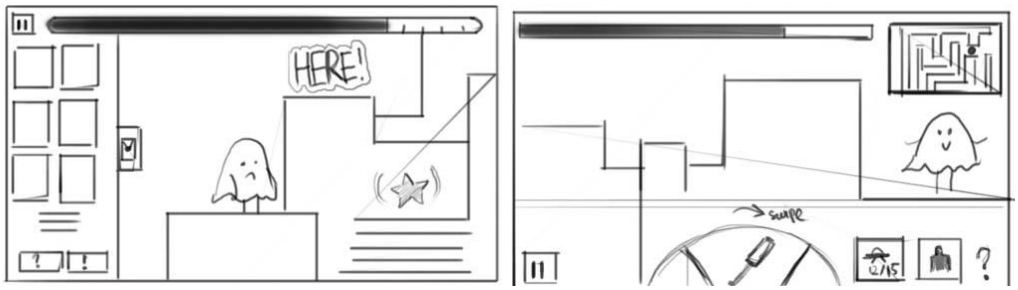

Figure 11 MA'LAM UI Mechanism Sketch (Digital)

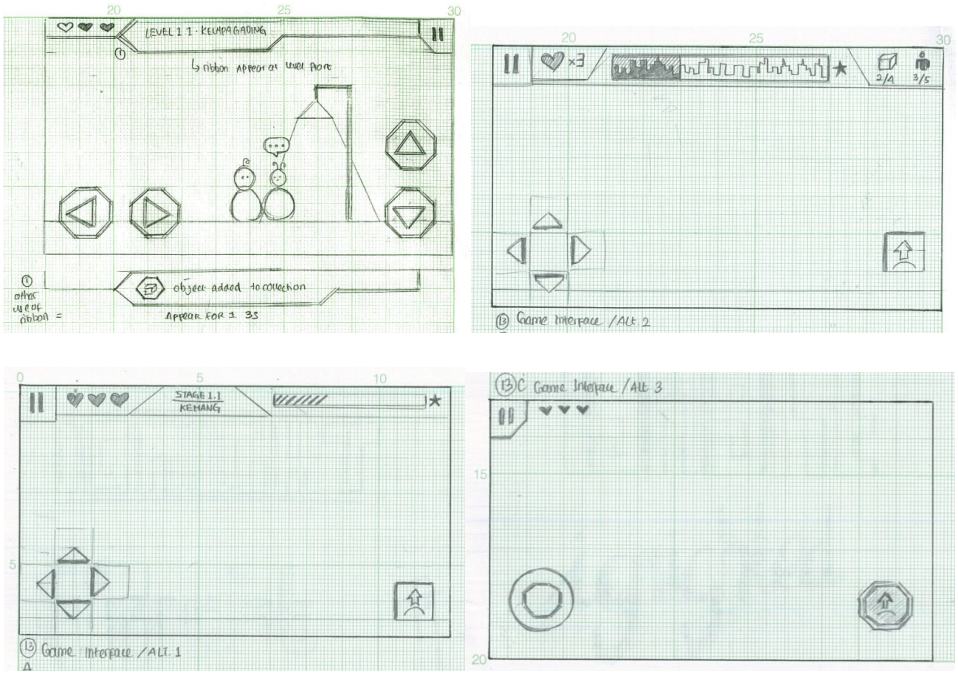

Figure 12 MA'LAM UI Layout Alternatives Sketch

Shown on Figure 11, the first prototype sketch reveals a heavily simplified gameplay interface that accommodates character interaction through touch gestures. But throughout the project, game mechanism was revised in alignment with character and environment design development, thus the later sketches as shown on figure 12 feature a digital toggle buttons for character movement to accommodate a more precise character movement within the zoomed out stage environment.

Figure 13 MA'LAM Digitalized UI Layout

UI prototype was actively iterated based on game engineers' feedback and user test results. Figure 13 shows the final version of gameplay interface that manifests the previously planned holographic sci-fi inspired interface. UI for gameplay evolves in both aesthetic and mechanism based on the collected feedback, such as the size and placement of buttons, revised icon, added interface feature (mission and hint button), and the form and mechanism of HP bar.

5. UI Analysis

The UI Analysis discussed below is related to gameplay mechanism and experience. Analysis is approached through aesthetic (form follows function/function follows form) and usability aspects.

5.1 MA'LAM's UI features

Navigation

Character navigation buttons affect the main character's movements. They give direct feedback when being tapped by changing color from yellow to green. There are 5 buttons to direct up, down, left, right, and jump movements. Navigation buttons were designed with a larger scale compared to other gameplay UI buttons to induce comfort and ease of access.

Directional Navigation Buttons *Jump Button*

Figure 14 MA'LAM Character Navigation Buttons

Directional buttons (up, down, left, right) as seen on Figure 14 are located on the left side of the screen to be operated with non-dominant hand (for right-handed players), while jump button requiring players' agile interaction is located on the right side. Another difference is directional buttons are operated by holding down buttons, while jump button is operated by quick tapping motion.

Playable Character Control & Inventory Management

Within MA'LAM, there are different types of character interactions such as collecting Non-Playable Characters (NPCs), Collecting Objects, and shooting Obstacles with an unlocked character special ability as shown in Figure 15.

Figure 15 MA'LAM Interaction Button Functions: Collect Character (1), Collect Object (2), Dialogue with NPC (3), Disable Obstacle/Shoot (4)

Figure 16 MA'LAM Character & Object Collection Feature: Collected Character/Object Notification Pop-Up on top of gameplay screen (upper left & right), Character Collection Menu Page (lower left), Object Collection Menu Page (lower right)

NPC and object collecting features are activated when players stood on a certain range within target. It is indicated when the icon on interact button changes to a person's profile or a lightbulb as shown in Figure 15 numbered 1 and 2. Collected items are accessible to view from MA'LAM's collection menu feature. The feature is related to MA'LAM's inventory management. After successfully collecting item players are notified through a green-colored pop-up on the top part of gameplay screen. The visualization of collection feature is shown in Figure 16.

Figure 17 MA'LAM Dialogue Sequence Screen Sample

Players can engage in a dialogue sequence with certain characters. The above figure shows a snippet of dialogue sequence on MA'LAM's first level. When dialogue is available, interact button's icon change to a dialogue bubble on a certain range within the targeted character. When dialogue is active, screen will zoom towards the interacting characters, UI buttons and features will be deactivated except for dialogue panel and pause button, and players may tap the dialogue panel to progress the occurring dialogue.

Playable Character Status Monitoring

MA'LAM status monitoring is differentiated into HP monitoring, mission checklist, and stage clear/game-over signifier. HP monitoring feature is linked with stage obstacles and triggered to respond when characters make contact with obstacles. When HP is depleted, HP bar decreases and the screen's border blinks red. HP bar is located on the right border of the screen and is visualized as energy bars with 5 parts from dark green (full) to dark red (almost-empty) as shown in Figure 18.

Figure 18 Red Border - Signify Encounter with Obstacle, HP Bar (right side of screen border)

The animated stage clear/game-over signifier inform players of their status in completing or failing a level. The red Game over signifier is mapped to appear when users' HP bar is depleted to zero. The green stage-cleared signifier is mapped to appear when players succeeded in reaching a stage's end. Visualization of these features is observable in figure 19.

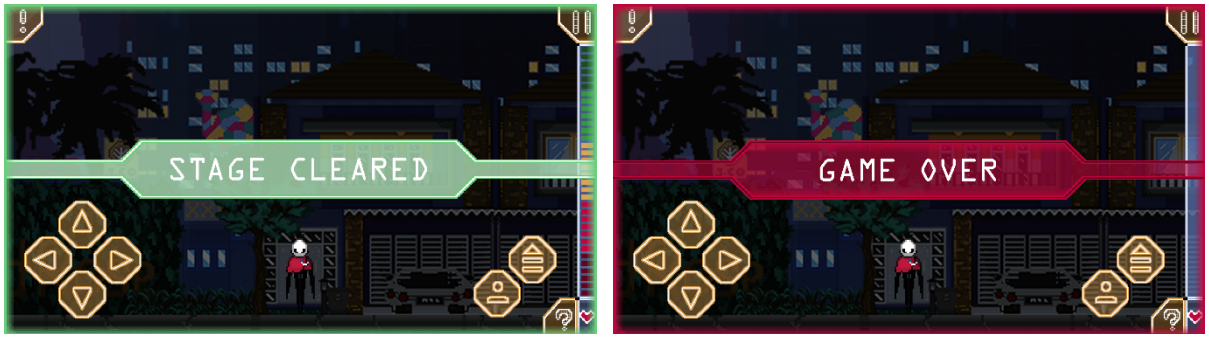

Figure 19 Stage Cleared & Game Over Animated Sequence Screen Capture

Figure 20 Mission Checklist Feature on Gameplay (left) & Level Menu (right)

Figure 20 illustrates Mission Checklist feature. Mission checklist is affordable to access throughout the gameplay and informs players about objectives required to complete within a particular stage. Checklist appears when players tap on mission button at the top left corner of the screen, distinguished by the exclamation mark icon. The stage mission checklist is also viewable from level menu when gameplay is paused.

Finding Help/Information with Tutorial / Virtual World Orientation

Alternative access to game tutorial is shown in Figure 21. Aside from first time starting level 1 of MA'LAM, tutorial sequence can be replayed whenever by accessing Setting – Tutorial Menu from the game's main/pause menu. Game tips and instructions are given within tutorial sequence whenever users tap on device screen. When users do so, tutorial will continue from the present tutorial image frame to the next frame.

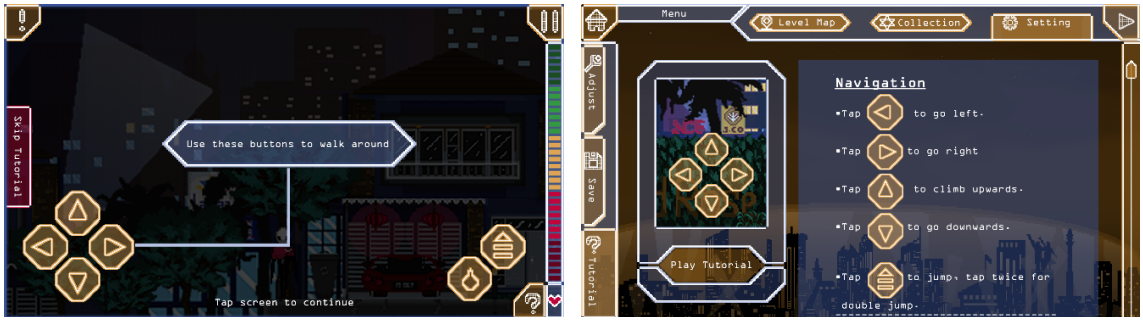

Figure 21 Tutorial Page on Setting Menu (left), Tutorial Sequence Sample (right)

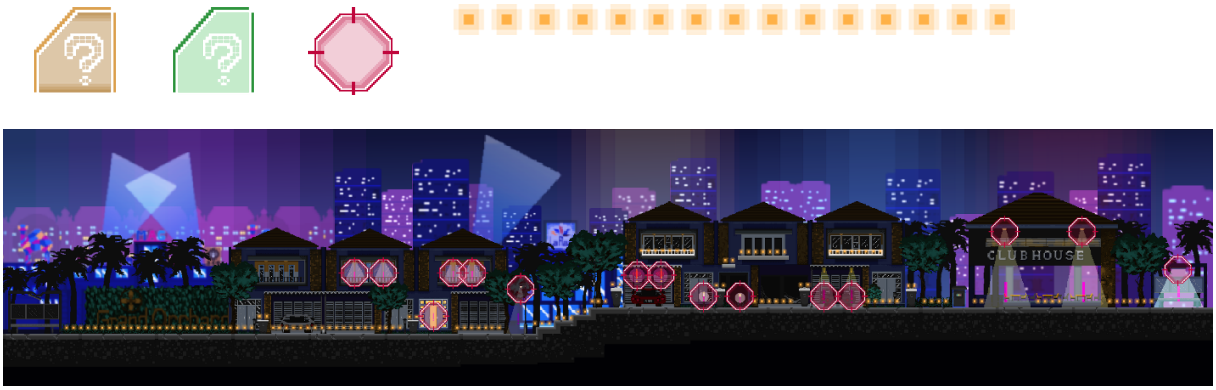

Figure 22 Hint Button (non-active & activated), Hint Signifiers (Red Target & Breadcrumbs), Hint Layer Sample on MA'LAM's First Level (lower picture)

Additional help/information is accessible within gameplay by tapping hint button on the bottom right side of the screen indicated by a question mark icon, expressed in Figure 22. When activated, a layer will appear throughout the current game stage, indicating the locations of obstacles as well as displaying breadcrumbs that direct players toward the end of the stage. Hint feature is related to MA'LAM's virtual world orientation to answer players' difficulty in navigating and differentiating crossable paths within gameplay.

5.2 MA'LAM's Usability

Learnability

Gameplay and UI's learnability are reinforced through game tutorial. Players may learn and improve their skills in playing by experiencing the game first-hand. Based on 26 beta test volunteers' feedbacks, a more detailed and action-guided tutorial is preferred.

Memorability

To support memorability, gameplay navigation is being made intuitive and aided with icons for visualization. To anticipate players forgetting how to operate gameplay, rules and game mechanic explanations are available to view from tutorial page on MA'LAM's setting menu.

Efficiency

Game efficiency was tested by game designers and developers that have already mastered the game mechanism on 6 game levels and 6 mini-games. Testing efficiency aims to shorten MA'LAM's duration of game completion so the full message of the game can be communicated swiftly and game mechanisms can be demonstrated on its full length with ease to game stakeholders.

Errors

Five chances to fail passing obstacles are given within MA'LAM's gameplay. When players fail, they are transported to the start of a level. Although each is relatively short, obstacles and paths are complexly placed for challenge. Difficulty increases as level progresses. To anticipate frustration, hints to navigate stage is offered.

Out of 26 volunteers, 42.3% claimed they often encounter errors due to lagging character movement, hard to maneuver obstacle course, and hard to solve mini-game on the higher levels.

User Satisfaction

User satisfaction is measured from 26 Beta test volunteers' survey entries. 83.8% volunteers felt entertained when playing. 84.6% claimed they don't feel bored while playing and 80.7% feel MA'LAM's gameplay and storyline are intriguing. 88.5% perceive the game's concept as being original. 50% felt exasperated when playing, although 65.5% respondents claim the game is simple and easy to understand, 69.2% felt challenged while playing. Moreover, 50% of volunteers rate the game with a medium difficulty level.

Based on qualitative feedback, MA'LAM gave a nostalgic experience of old-school games they played in childhood. The game is praised for its harmonious and pleasing character, stage, and interface visuals. The positive feedbacks by volunteer proves claim by Cooper, Reimann, Cronin, & Noessel (2014) about aesthetic quality affecting perceived usability. Regarding UI aesthetics, 92.3% volunteers are satisfied with the UI layout, claiming it is comfortable to view.

Simplicity

Simplicity is expressed within gameplay's UI through limited character controlling buttons. For example, there is only one interact button with multipurpose uses. Simplicity is also expressed with limited UI gestures (tapping/ holding down buttons, occasional swiping motion). Simplicity is achieved by designing game mechanism before listing down required UI assets and features so that every UI feature has a distinct necessity and is an integral part of gaming experience.

Comprehensibility

Comprehensibility about game message is communicated through game storytelling and game mechanism. Both are implemented within UI features such as character dialogue, collection menu contents, and mini-games. 80.8% respondents perceive information communicated by MA'LAM as clear and comprehensive, while 76.9% claim they know about light pollution better after playing the game.

5.3 Light Pollution Awareness

Survey with 110 respondents from Empathise Phase reveals that 44.5% claim to be not familiar with light pollution issue in Jakarta. The majority of 55.5% who claims familiarity possess misconceptions about light pollution as shown on collected qualitative data. Interviews from target users reveals that light pollution was discussed at education institutions, but the subject leave no significant impression and are soon forgotten. This claim is supported with the fact that targeted users don't perceive direct disadvantage from light pollution. In-depth interview with Jakarta Planetarium representative reveals insight that one of the main purpose of raising awareness is so that Jakarta Citizens would question the need of using an excessive amount of artificial lighting. But what hinders citizens from taking an act against light pollution is a misconception that light pollution is harmless. Hence, one of MA'LAM's main purpose is to communicate light pollution's harm through gameplay.

Beta test survey conducted after the project is finalized reveals that 80.8% claim to comprehend MA'LAM's intended message. 76.9% agree that they are more aware about light pollution after completing the game. The message was received through gameplay that 50% players perceive as having medium level difficulty. Further collected data reveal 92.3% are satisfied with interface layout which are intended to raise gameplay engagement that triggers heightened perception towards MA'LAM's intended message.

6. Conclusion

MA'LAM is an informative mobile game about light pollution in Jakarta. The game message is conveyed with support from UI design that put a focus on function-aesthetic development and mobile game usability qualities. For development, Design Thinking Method was implemented.

Player's positive engagement with MA'LAM's gameplay is supported by its well-received UI, both within gameplay and related menu features. Positive feedbacks indicate the designed mobile game is a possible alternative media to increase awareness about light pollution issue in Jakarta. It is worth noting that aside from UI alone, players' interaction with game mechanism and storytelling aspects plays a major role to induce engagement.

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